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ON THE DISTRIBUTION OF THE ITALIAN NEWT *LISSOTRITON ITALICUS* (PERACCA, 1898) IN THE MARCHE REGION: NEW OBSERVATIONS AND PREDICTIONS

SUMMARY

The distribution of the Italian endemic species *Lissotriton italicus* is poorly known in the Marche, where it reaches the northernmost limit of its distribution. In this study the presence of the species was reported thanks to new observations on its regional distribution. A total of 29 georeferenced data, including both old and new records, were used to generate a species distribution model and perform an analysis of the bioclimatic preferences of the species in the region. The resulting bioclimatic model indicates that 25% of the study area is suitable for *L. italicus.* However, in the northern part of the region the species appers to be absent. It is argued that the presence of ecological and geographical barriers, as well as the competition with the co-occurring species *L. vulgaris meridionalis*, could explain the current distribution of the Italian newt in the Region. Future studies will help improve understanding this distribution pattern and guide appropriate conservation strategies.

Key words: endemism, species distribution modelling, MaxEnt.

RIASSUNTO

Distribuzione del tritone italico Lissotriton italicus *(Peracca, 1898) nelle Marche: nuove osservazioni e predizioni.* La distribuzione del Tritone italiano *Lissotriton italicus*, specie endemica dell'Italia centro-meridionale, è ancora poco conosciuta per le Marche, regione dove raggiunge il limite settentrionale del suo areale. In questo articolo vengono riportate nuove osservazioni regionali raccolte negli ultimi anni (2018-2021). In totale, 29 dati georeferenziati, tra vecchie e nuove segnalazioni, sono stati utilizzati per elaborare un modello di distribuzione che tiene conto delle preferenze bioclimatiche della specie. Nonostante il modello evidenzi una vasta area di idoneità ambientale per *L. italicus* nelle Marche, nella parte settentrionale della regione la specie sembra essere del tutto assente. La presenza di barriere geografiche ed ecologiche, ed in parte la competizione con la specie vicariante *L. vulgaris meridionalis*, possono descrivere l'attuale distribuzione del Tritone italiano. Future indagini di campo potranno chiarire meglio tale distribuzione ed orientare le strategie per la conservazione.

Parole chiave: endemismo, modello di distribuzione, MaxEnt.

INTRODUCTION

The Italian newt *Lissotriton italicus* (Peracca, 1898) is endemic to the southern- and central regions of mainland Italy (SINDACO *et al.*, 2006; LANZA *et al.*, 2009). It inhabits a wide variety of natural and artificial habitats, from small, still water bodies (e.g., water tanks, small ponds and pools) to slow-flowing streams. In the Marche, where the species reaches its northernmost distribution, observations are few and/or dated (FIACCHINI, 2003, 2013; FIACCHINI *et al.*, 2006). To improve the current knowledge on the distribution and status of the regional populations of the species, surveys were carried out from February 2018 to April 2021. The surveyed sites were selected on the basis of the presence of optimal reproductive environments and minimum anthropogenic disturbance. Individuals were visually observed in their habitat without any sort of manipulation. Through these systematic surveys, 3 previously known sites were confirmed and 11 new ones were detected, adding 4 new 10x10 km cells to the applied grid (17 cells, equal to 13% of regional UTM squares; Fig. 1). The old and new records (29 georeferenced points) were pooled together for further analyses.

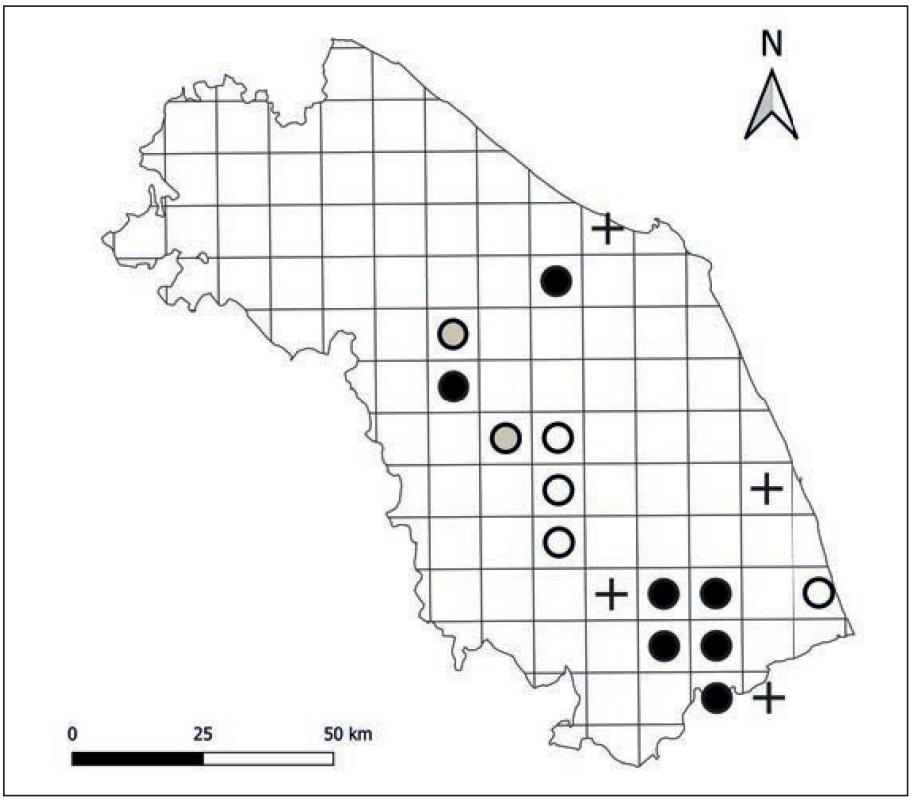

Fig. 1 — Updated distribution of *Lissotriton italicus* in the Marche. Black dots indicate previously known 10 x 10 km cells; gray dots indicate previously known cells with new sites; white dots indicate new cells; and crosses indicate known cells not used for the model.

In order to predict and prioritize locations for future surveys of *L. italicus* in the Marche, a bioclimatic suitability map of the species was generated via maximum entropy modelling (MaxEnt 3.4.0; PHILIPS *et al.*, 2006). Altitude, as well as 19 bioclimatic variables, were downloaded from the WorldClim 2.1 database (https://www.worldclim.org). All layers featured a 30 arcsec spatial resolution and were clipped to the extent of the study area. To eliminate spatial collinearity among predictors, a Pearson's correlation matrix was calculated in R 3.6.1 (R Core Team, 2019). For each pair of correlated variables ($|r|>0.75$), the most relevant to the biology of *L. italicus* was retained. The following variables were selected: bio04 (temperature seasonality); bio06 (minimum temperature of the coldest month); bio07 (annual temperature range); bio09 (mean temperature of the driest quarter); bio14 (precipitation of the driest month); bio15 (precipitation seasonality); and bio18 (precipitation of the warmest quarter). A total of 30 replicates were computed in MaxEnt (default settings), each with 70% of data points randomly used for training and 30% for model validation. Jackknife analysis was applied for estimating relative contribution of each predictor variable to the final model. Model performance was evaluated based on average omission rate (OR) and area under curve (AUC) statistics. AUC is a measure of the model's discriminatory ability between presence and background points. A model with low detectability will have AUC values closer to 0.5 (indicating no greater fit than expected by chance), whereas a model with high detectability will have values closer to 1.0 (indicating perfect model fit; ELITH *et al.*, 2006). The average model prediction was used to produce the habitat suitability map for *L. italicus*, showing that about 25% of the study area is considered reasonably suitable (i.e., with scores > than 0.4) for the species (Fig. 2). The suitable area is mostly concentrated around the hilly and foothills environments of central and southern Marche (i.e., Natural Regional Park "Gola della Rossa e di Frasassi", Natural Regional Reserve "Monte San Vicino e Monte Canfaito", mountains from Fabriano to Sefro, hills from Cingoli to San Severino Marche, hills from Camerino to Ascoli Piceno and forests between Cupramarittima and Ripatransone), with isolated patches in the North and on the coastline (Natural Reserve "Gola del Furlo" and Regional Park "Conero"). The average AUC for 30 replicated runs was 0.910 ± 0.035, indicating high model performance in predicting the species occurring pattern.

The distribution of the Italian newt in the Marche is still fragmented. However, our results highlight a trend towards Mediterranean, mid-altitude habitats, similar to the species habitat in southern Italy. There are isolated areas of suitability proposed by the model, where no data are reported, such as on Regional Park "Conero" and the Central Apennine near Umbria. These could not be easily reached by the species due to geographical and ecological barriers, and the

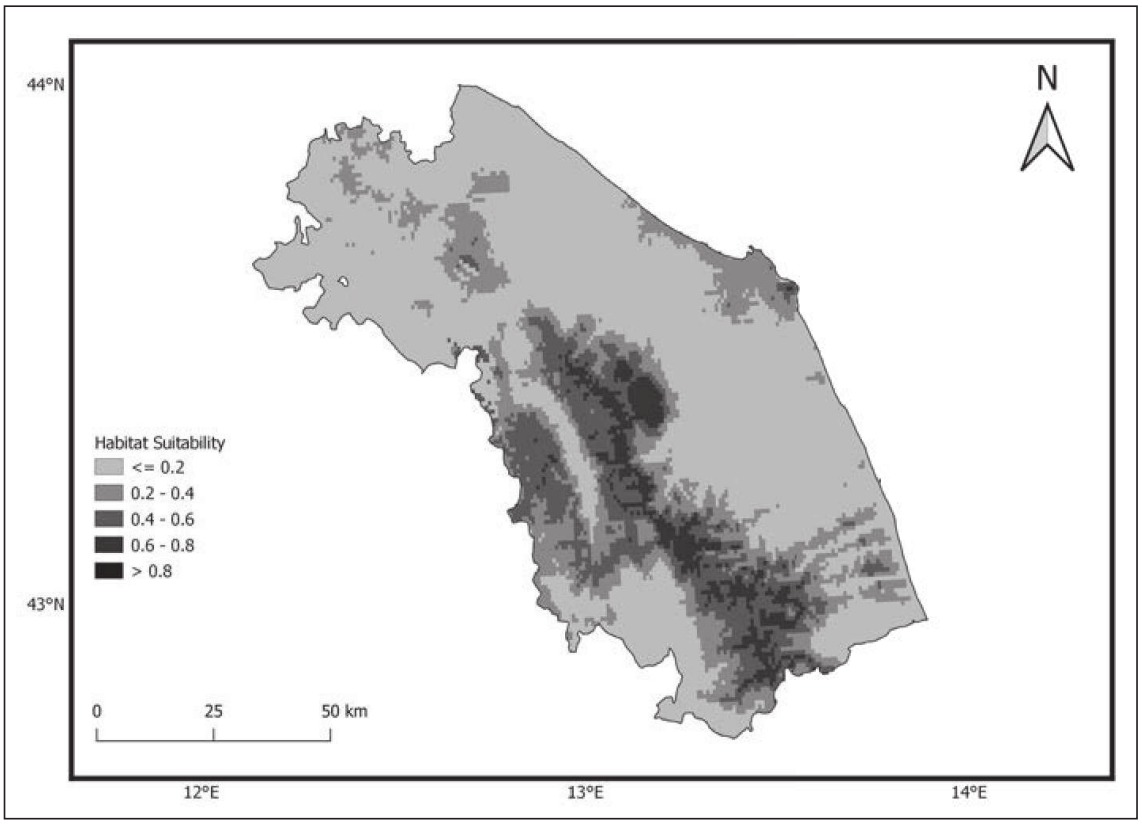

Fig. 2 — Species distribution model for *Lissotriton italicus* in the Marche based on maximum entropy algorithm (MaxEnt 3.4.0; Philips et al., 2006). Darker colours indicate higher bioclimatic suitability.

co-occurring species *L. vulgaris meridionalis*, determining possible competitive displacement (IANNELLA *et al.*, 2017; MIRABASSO *et al.*, 2020). Furthermore, environmental and anthropogenic factors such as land use, intensive agriculture and human pressure, mainly in lowlands, may have separated existing populations of *L. italicus* or blocked the dispersal of individuals, preventing the colonization of new sites. Further investigations are recommended to improve the knowledge of the current distribution of this Italian endemic species in the Marche, also in order to guide appropriate conservation strategies.

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